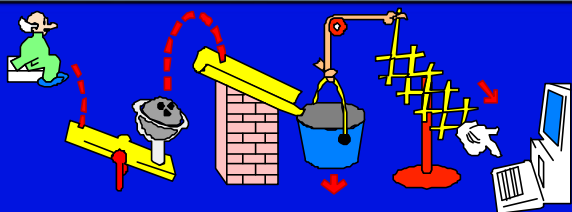



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Change Impact Analysis



Change Impact Analysis

August 8, 2000
Leanna Rierson
National Resource Specialist
for Aircraft Computer Software
Leanna.Rierson@faa.gov

Slide 1




History (1/2)

- Major/Minor change classification issues have existed for years.
- 1993-1996 - Certification Authorities Software Team (CAST) developed a position paper on major/minor software classification.
- 1998 - Streamlining Software Aspects of Certification (SSAC) Industry Workshop participants raised issue regarding FAA policy on major/minor software changes.

Slide 2

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Change Impact Analysis



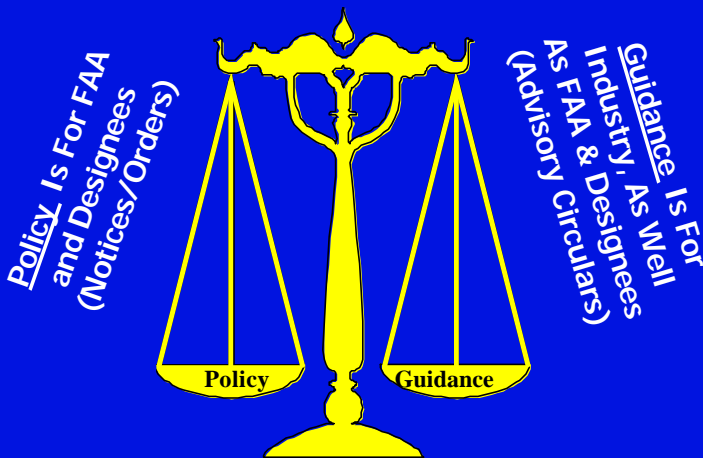
History (2/2)

- 1998-1999 - FAA and industry worked together to develop a position addressing major/minor classification of software changes.
- Result: Software change impact analysis guidelines.
- Policy: Notice entitled "Guidelines for the Oversight of Software Change Impact Analysis Used to Classify Software Changes As Major or Minor."
- Status: Notice Signed on May 11, 2000

Slide 3



Policy vs. Guidance



Policy Is For FAA and Designees (Notices/Orders)

Guidance Is For Industry, As Well As FAA & Designees (Advisory Circulars)

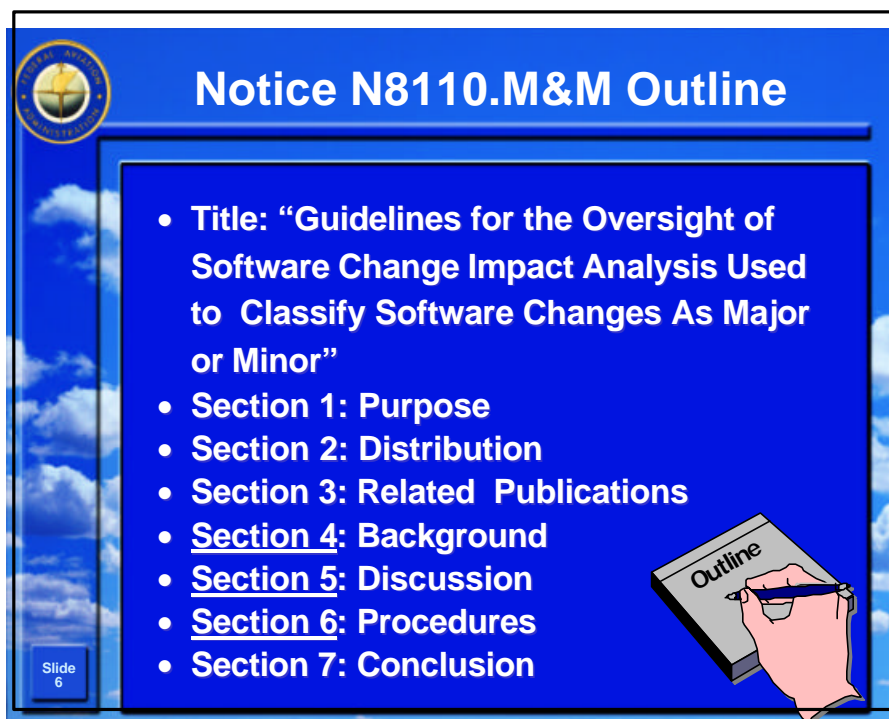
Policy

Guidance

Slide 4


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Change Impact Analysis



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Change Impact Analysis



Section 1-3: Purpose, Distribution, Related Publications

- **Section 1 - Purpose**
 - To provide a standardized process for assessing the safety impact of software changes & determining FAA's involvement in software changes
- **Section 2 - Distribution**
 - FAA and designees
- **Section 3 - Related Publications**
 - Advisory Circular 20-115B
 - RTCA/DO-178B
 - Part 21
- **Note:** Notice N8110.78 on Legacy Systems is also related

Slide 7

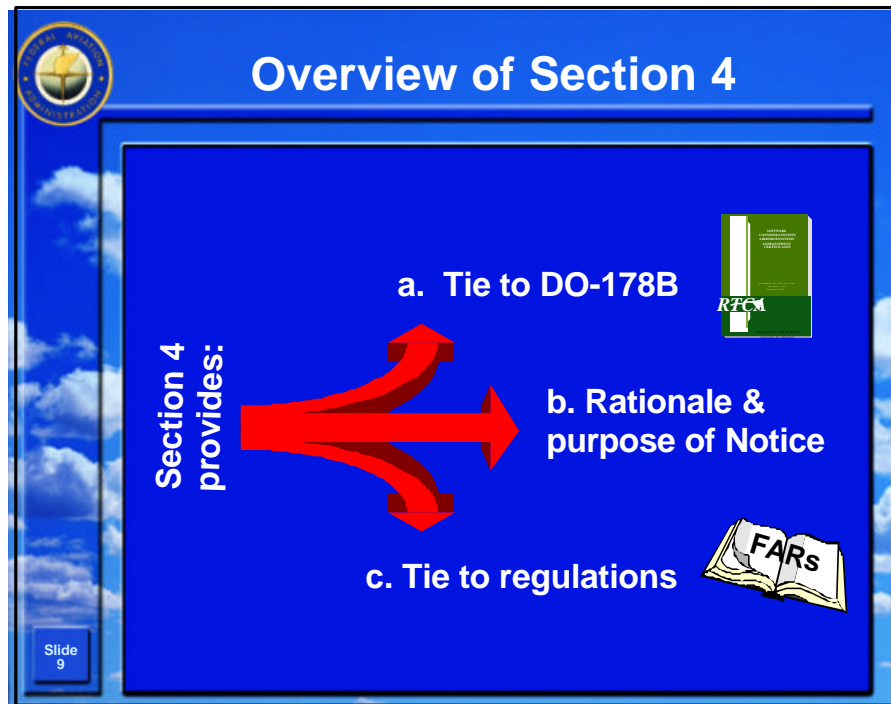



Section 4 - Background

Slide 8


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Change Impact Analysis



 **Tie to DO-178B**


- AC 20-115B recognizes DO-178B as a means of compliance to the FARs
- DO-178B addresses software changes in Section 12.1



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Change Impact Analysis




Tie to Regulations


- Regulations address major/minor changes in:
 - 21.93(a) and 21.95 - Type Certification
 - 21.611(a), (b) - Technical Standard Order (TSO)
- Regulations look at changes from the product perspective



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FAR Quotes (1/2)




- 21.93(a) states that a “**minor change**” is one that has no appreciable effect on the weight, balance, structural strength, reliability, operational characteristics, or other characteristics affecting the airworthiness of the product. All other changes are ‘major changes’ ...”.
- 21.95 states: “**Minor changes** in a type design may be approved under a method acceptable to the Administrator before submitting to the Administrator any substantiating or descriptive data.”

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FAR Quotes (2/2)


- 21.611 (a) and (b) addresses “minor” and “major” changes for TSO manufacturers. 21.611(a) basically says that minor changes (i.e., a change that’s not major) may be made without further approval by the FAA. The revised data should be submitted to the appropriate ACO. 21.611 (b) states that “**Any design change by the manufacturer that is extensive enough to require a substantially complete investigation to determine compliance with a TSO is a major change.**”

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Types of Software Changes (1/2)


- Pre-Certification
 - During software development/before software approval
 - Change control in place
 - Problem reporting & correction in place
 - Re-verification in place
 - Addressed in Sections 7 & 8 of DO-178B



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Change Impact Analysis




Types of Software Changes (2/2)

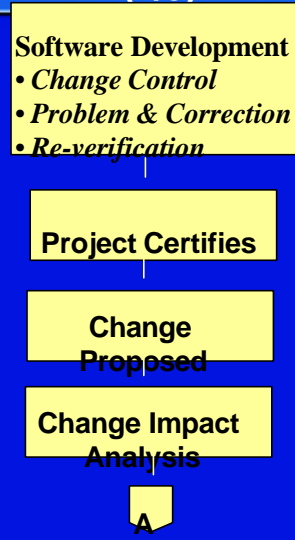
- **Post-Certification**
 - After software approval and product certification
 - Section 12.1 of DO-178B (“Use of Previously Developed Software”) addresses this kind of change
 - N 8110.M&M focuses on the post-certification change



Slide 15



Big Picture Look at Software Changes (1/3)

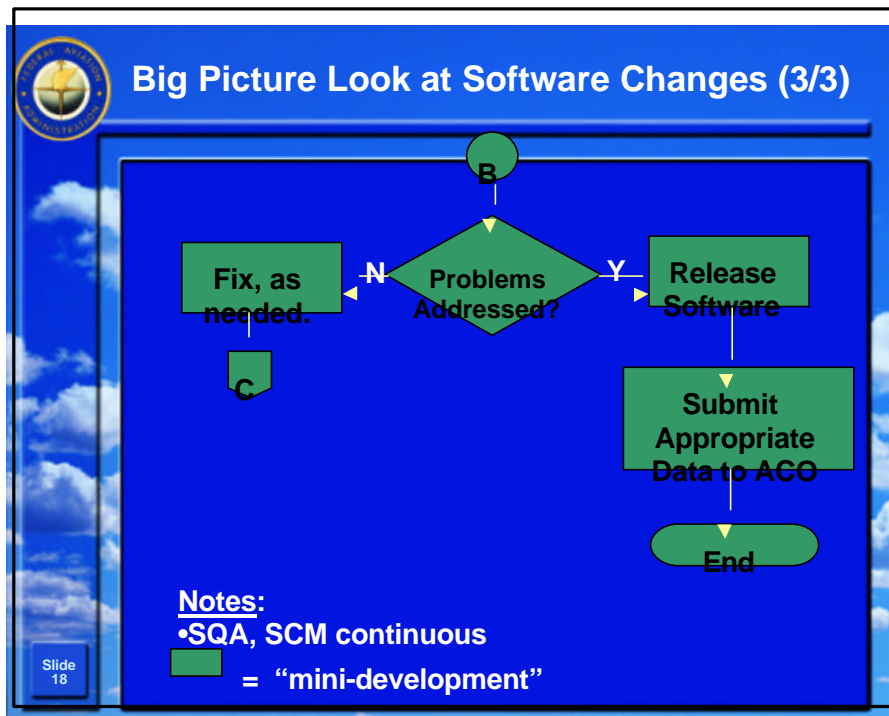
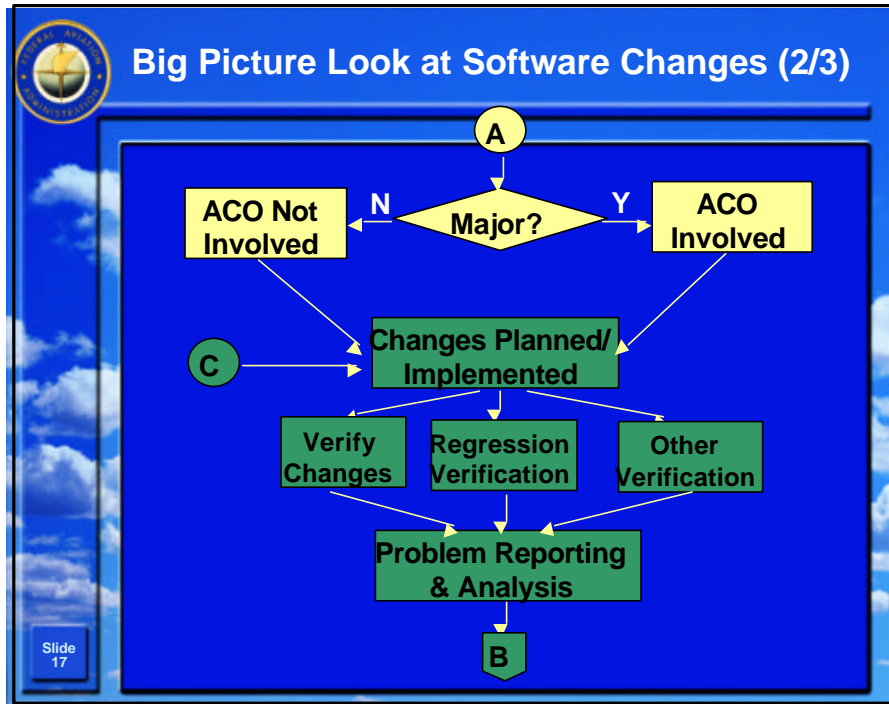


```
graph TD; A[Software Development<br/>• Change Control<br/>• Problem & Correction<br/>• Re-verification] --> B[Project Certifies]; B --> C[Change Proposed]; C --> D[Change Impact Analysis]; D --> E[A];
```

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Change Impact Analysis




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Change Impact Analysis

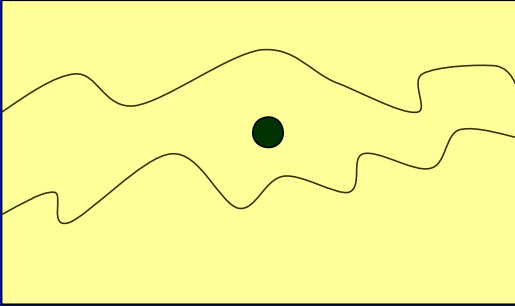
 Purpose of Change Impact Analysis (1/2)

- Assess affects of the software change on system performance, safety, documentation, ...
- Assess the classification of the change (E.g., major, minor, significant, insignificant)
- Determine amount of rework and verification required
- Plan for the change (resources, cost, schedule, ...)

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 Purpose of Change Impact Analysis (2/2)

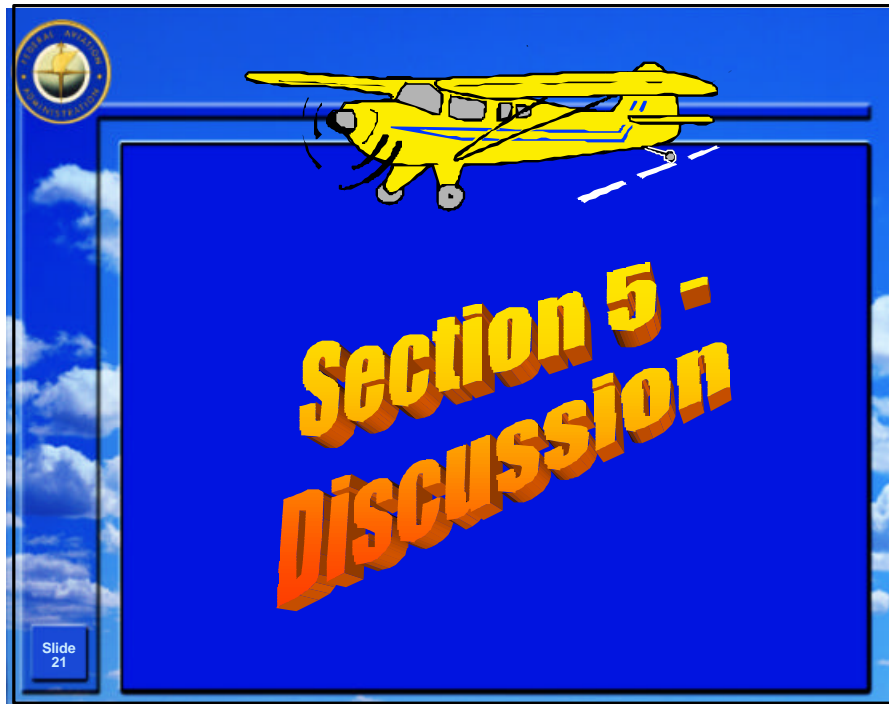
- Identify what is affected by the change



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Change Impact Analysis


This slide has a blue background with a vertical strip of clouds on the left side. The FAA logo is in the top left corner. The title "Overview of Section 5" is centered at the top in white. Below the title is a list of bullet points in white text. A small box in the bottom left corner contains the text "Slide 22".

Overview of Section 5

- Technical “meat” of the Notice
 - “WHAT”, not “HOW”
- 3 Sub-Sections:
 - 5a) Items to be addressed by CIA, as applicable
 - 5b) Examples of changes that could cause adverse affects
 - 5c) Updating data & verification

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Change Impact Analysis



Section 5a: Potential Items to Be Addressed in CIA

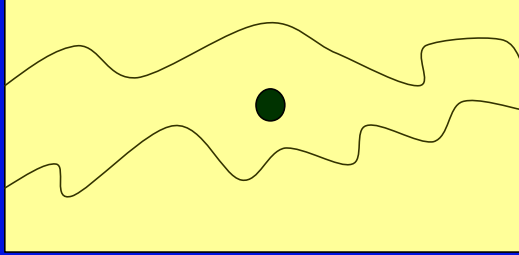
- Traceability Analysis
- Memory Margin Analysis
- Timing Margin Analysis
- Data Flow Analysis
- Control Flow Analysis
- Input/Output Analysis
- Development Environment & Process Analyses
- Operational Characteristics Analysis
- Certification Maintenance Requirements (CMR) Analysis
- Partitioning Analysis

Slide 23



Traceability Analysis


- **VERY IMPORTANT!**
- Identifies areas affected by the software change:
 - Requirements & Design Analysis
 - Code Analysis
 - Test Procedures and Cases Analysis



Slide 24

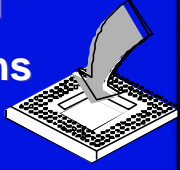
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Change Impact Analysis




Memory Margin Analysis

- Assure memory allocation requirements and margins are maintained.
- Examples of tasks:
 - Estimate change to flash memory
 - Estimate change to RAM
 - Evaluate memory margins



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Timing Margin Analysis

- Assure timing margin issues are not introduced due to the change.
- Examples of tasks:
 - Review timing requirements
 - Review CPU task scheduling requirements
 - Review interface timing requirements
 - Review changes to the timing margins (usually want at least 10% margin)
 - Review throughput change for each task

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Change Impact Analysis



Data & Control Flow Analysis

- DO-178B, Table A-7, Objective 8 requires data & control coupling for Levels A, B, and C software.
- Data & control flow analysis assesses changes in data & control flow and coupling between software components.
 - Examples of software components are procedures and functions.
- Data & control flow analysis also evaluates any adverse affects due to the change.

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Input/Output Analysis

- I/O Analysis evaluates impact of the change on the interface with the external world:
- Examples of tasks:
 - Bus loading
 - External databus I/O
 - External hardwire I/O
 - Access to memory
 - Communication with hardware

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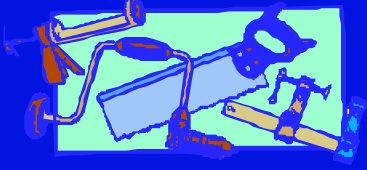
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Change Impact Analysis




Development Environment & Process Analysis

- Identifies changes in the environment or process that might have adverse affects on the system:
- Examples include changes to:
 - Compilers
 - Linkers
 - Loaders
 - Tools



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Operational Characteristics Analysis

- Identifies adverse effects in the operational environment due to software changes.
- Examples of changes that could affect the operation of the product:
 - Gain changes
 - Limit changes
 - Filter changes
 - Interrupt changes
 - Exception handling changes
 - Fault mitigation changes

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Change Impact Analysis




Certification Maintenance Requirements (CMR) Analysis

- Determines if the software change requires new or modified CMR.
- Example:
 - Assume the software change to the anti-skid systems increases the time that the brakes are applied during landing. This could result in more frequent maintenance of the brakes and tires.

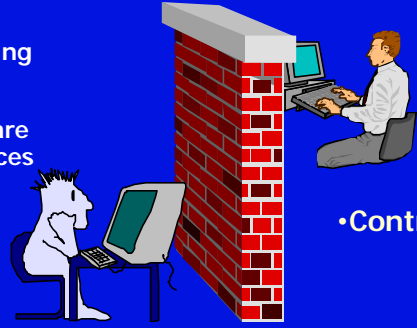


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Partitioning Analysis


- Determining the affect of the software change on the protective mechanisms.
- Data Coupling
- Hardware Resources
- Other Failure Modes
- Control Coupling



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Change Impact Analysis

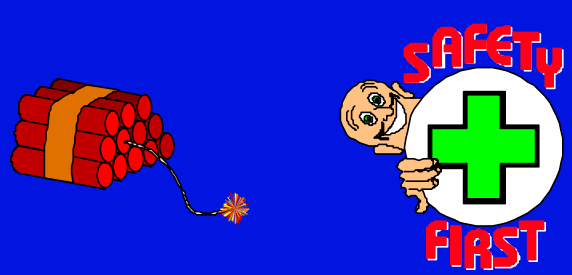
 Section 5b. Examples of Adverse Affects (1/2)

- When performing the CIA activities, the focus is going to be on adverse affects. I.e., things that affect operation and safety.
- Section 5b provides examples of typical categories of change impact:
 - Change in safety-related information
 - Change in operational or procedural characteristics of the aircraft
 - New functions
 - Different interfaces
 - Significant change to life cycle data

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 Section 5b. Examples of Adverse Affects (2/2)


- Changes that have adverse impacts will likely lead to a “major” change classification.



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Change Impact Analysis



5c. Updates and Verification


- Applicant updates necessary software life cycle data, whether the change is major or minor.
- Applicant verifies the software change to make sure there are no adverse effects. Example verification activities:
 - Reviews
 - Analyses
 - Regressions testing
 - Requirement-based testing
 - Flight testing

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Changes to Requirements (most common change)


- new
- modified
- deleted



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Change Impact Analysis



Developer's Role For New/Changed Requirement (1/4)

- Perform CIA to assure that the new or changed requirement:
 - does not conflict with other requirements
 - is unambiguously stated and verifiable
 - is verified to meet requirements of software level
 - achieves desired functionality

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Developer's Role For New/Changed Requirement (2/4)

- Assure that the following are completed, as needed:
 - update the software architecture
 - change prologue headers
 - review changes against standards
 - update traceability (both forward and backward)

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Change Impact Analysis



Developer's Role For New/Changed Requirement (3/4)

- Examine data elements to assure that new or changed code does not negatively impact existing functionality by:
 - examining all areas of the code that use the same variables as those in the changed or new code
 - re-examining variable declarations and interfaces
 - examining control flow to assure that the change does not negatively impact execution sequence or timing

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Developer's Role For New/Changed Requirement (4/4)


- Assure that:
 - Verification test cases for new and changed requirements exist
 - All requirements-based tests (normal and robust) that trace to new or changed requirements are run or re-run
 - Structural coverage is achieved for new or changed area, and still achieved for areas of code with dependencies
 - Verification record that documents the regression analysis exists

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Change Impact Analysis

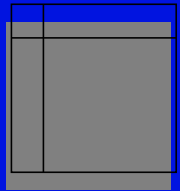
 **FAA's Roles For New/Changed Requirement**




- **Oversee the applicant's activities, when the change is "major"**
- **Oversee designees**
- **Perform on-site or desk-top reviews, as needed**

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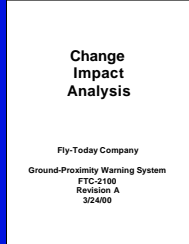
 **Examples of Change Impact Analyses (1/2)**



Tables/Forms



Automated Tools




Formal Reports

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Change Impact Analysis



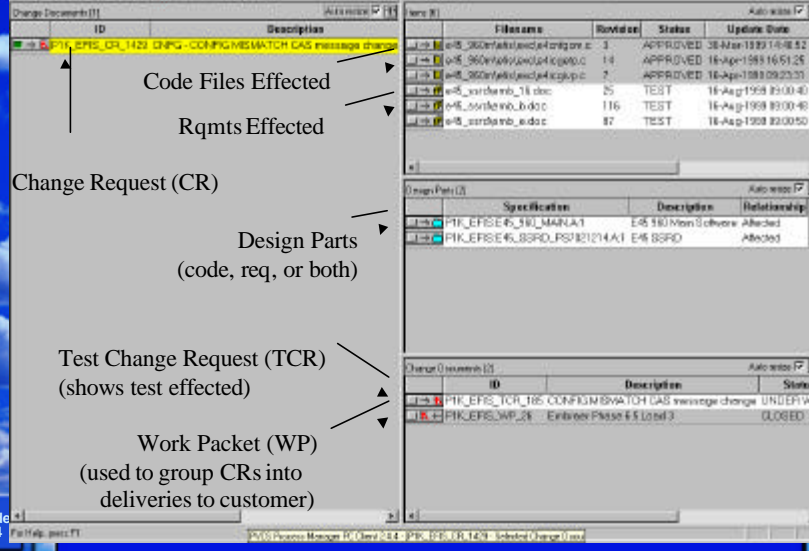
Examples of Change Impact Analyses (2/2)

- CIA's come in many forms
 - Some Formal
 - Some Informal
- No single correct format
- Extent of analysis depends on the change size and affected items
- Important to have the information available to make the necessary decisions

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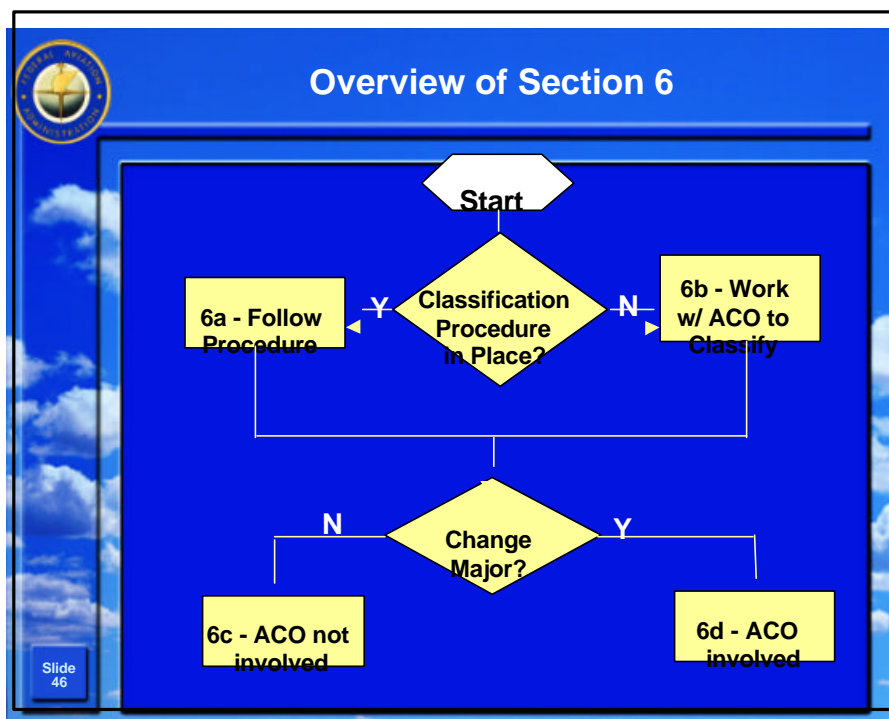
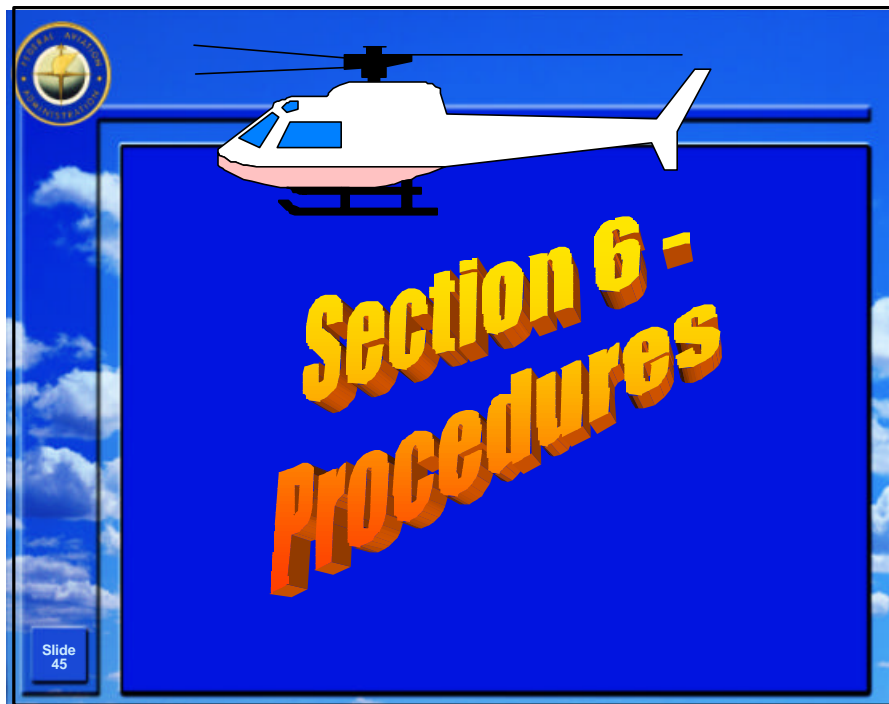
Example of a Tool Used in CIA



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Change Impact Analysis



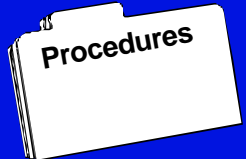
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Change Impact Analysis




6a - Applicant Has Classification Procedures (1/2)

- Procedures in place to classify changes as major or minor
- Reference FAR Part 21
- Procedures should be reviewed & approved by the ACO



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6a - Applicant Has Classification Procedures (2/2)

- Procedures should contain a process for:
 - Using CIA to classify change
 - Reviewing/approving the classification
 - Addressing minor changes
 - Addressing major changes
 - Informing FAA (e.g., PSAC, SAS, report, ...)
 - Obtaining FAA concurrence on changes

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Change Impact Analysis




6b - Without Classification Procedures


- FAA more involved
- Applicant performs CIA (using Notice)
- Applicant proposes classification (major or minor) to FAA
- FAA reviews/accepts/modifies the classification
- Applicant & FAA follow 6c for minor changes and 6d for major changes



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6c - Minor Changes




- Change performed without FAA involvement
- Data updated, as required
- Software Accomplishment Summary (SAS), Software Configuration Index (SCI), and/or other documents submitted to FAA on a periodic basis


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Change Impact Analysis




6d - Major Changes




- FAA and/or DER involved
- PSAC and/or CIA submitted to FAA as agreed upon
- SAS, SCI, and/or other agreed upon data submitted to ACO
- ACO and/or DER reviews and approves data, as needed

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Section 7 - Conclusion

- Notice is only a supplement AC 20-115B and DO-178B
- Guidelines only
- Variance from national policy should be coordinated with AIR-130



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Change Impact Analysis




Video Availability

- May 12, 2000 - Interactive Video Teletraining Delivered to FAA
- Videos Available for Designees and Industry
- Self-Study Guide & Order Form Available on Web-site:
 - <http://av-info.faa.gov/software>



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Summary

- Purpose of Notice is to provide guidelines for addressing changes to software.
- Intended to allow flexibility but encourage more standardization.
- Notice encourages use of CIA to serve as input into the major/minor classification.
- Send comments, questions, etc. to myself and/or Dennis.Wallace@faa.gov.

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